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Project Summary

Quality Assurance in Support of Energy Related Monitoring Activities: Final Report

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This summary describes the activities and achievements of Rockwell International's Environmental Monitoring & Services Center (EMSC) during the four and a half years of the program entitled, *Quality Assurance in Support of Energy Related Activities*. The activities reported cover the period from July 13, 1976 to December 31, 1980.

The purpose of this program was to establish a quality assurance program to provide a data base for ambient air monitoring in specified geographical areas around present and proposed energy development projects, and to provide technical assistance to enable existing monitoring networks to achieve a high level of data quality. A major goal of the program was to give the U.S. Environmental Protection Agency (EPA) access to monitoring data from diverse sources for future study and planning purposes. This goal involved providing information concerning data quality from the individual monitoring networks.

The scope of work was divided into four task areas involving: (a) Quality Assurance System Audits, (b) Quality Control Reference Sample Audits, (c) Calibration Performance Audits, and (d) Technical Assistance to the Laboratories.

A total of thirty-six laboratories and associated field sites were visited, inspected, evaluated, and the findings summarized in detailed system audit reports submitted to EPA.

Regularly scheduled Quality Control Reference Sample Audits were conducted for the analysis of sulfate, nitrate, sulfur dioxide, nitrogen dioxide, and carbon monoxide, and for filter weight measurement and high-volume flow rate.

Over 420 performance audits at the field stations were conducted to check for calibration accuracy of continuous analyzers. In these audits, known concentrations of pollutants were delivered to each continuous analyzer, and the observed response was compared with that predicted by the operating agency's calibration. Procedures were developed to assure reliable performance by the audit devices and standards. Additional checks on the equipment and procedures were made by means of quarterly audits performed at EPA's Environmental Monitoring and Systems Laboratory at Research Triangle Park, North Carolina.

In addition to audit activities, technical assistance was provided to participating agencies as requested by the Project Officer. Much of this assistance was given informally during site visits. During special visits by Rockwell personnel, assistance was also provided concerning specific laboratory and calibration problems. The major technical assistance areas

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were in air monitoring and quality assurance procedures, chemical analysis and quality control procedures, trace metal analysis, traceability to NBS, special audits, and guideline reviews.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This project summary outlines the activities of Rockwell International Environmental Monitoring and Services Center (EMSC) pursuant to Contract No. 68-02-2412, entitled *Quality Assurance in Support of Energy Related Monitoring Activities*. This program was initiated on July 13, 1976, and work continued until December 31, 1980, a period of about four and a half years.

During the course of the program, several modifications to the initial scope of work occurred. On March 24, 1977, the contract was enlarged to include additional Quality Assurance System Audits and Performance Audits of Region VIII sites in Colorado, Utah, and Montana. On August 9, 1977, the contract was further expanded to include Quality Assurance System Audits of seven water quality field stations of the U.S. Geological Survey in the states of Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming.

A major modification to the contract occurred on September 13, 1978, when the program was expanded to include approximately sixteen additional organizations, each operating laboratories and air monitoring stations in the Ohio and Tennessee Valleys and in several eastern states in Region III. At the time of the modification, the work for Region VIII (initiated on March 24, 1977, as described above) was extended for an additional 12 months. At the request of EPA, the participation of the Ohio and Tennessee Valley groups as well as that of the eastern groups came to an end in April, 1979.

On April 22, 1979 another modification required the EMSC to conduct additional Quality Assurance System Audits of nine water quality stations of the U.S. Geological Survey in Alabama, Illinois, Indiana, Kentucky, Mississippi, Ohio, Pennsylvania, Tennessee, and Virginia. As part of the effort, an executive summary was required covering the seven water sites inspected in 1977 and the nine water sites inspected in 1979.

In this summary, reference is made to the Western Quality Assurance Program and to the Eastern Quality Assurance Program. This delineation of the program is employed for convenience in describing work according to the geographical location of the participating groups.

The purpose of both Quality Assurance (QA) Programs was to develop and implement a quality assurance program related to air quality monitoring activities around present and proposed energy development projects. The intent of this program was not to support operators responsible for prevention of significant deterioration (PSD) air monitoring (PSD statutory requirements were not in effect when the program was initiated), but rather to enable the government to utilize and compare air monitoring data from diverse sources for future study and planning purposes by providing information concerning data quality from the monitoring networks. A secondary goal was to provide technical assistance to the participating groups to help them achieve a high level of performance. In the West, the energy projects were located in Montana, South Dakota, North Dakota, Wyoming, Utah, Colorado, Arizona, Nevada, New Mexico, and California. In the East, the energy projects were located in West Virginia, Ohio, Pennsylvania, and Indiana. Additional groups associated with the Eastern QA Program but not involved in energy development projects were located in Delaware, Maryland, Virginia, and the District of Columbia.

This summary is a general overview of performance and accomplishment. During the course of the program, many detailed reports were submitted to EPA describing specific tasks, as well as three annual reports and a final report. In order to keep this summary within manageable size, the reader will oftentimes be directed to these specific reports, should greater detail be required.

Conclusions

The Eastern and Western Quality Assurance Programs were divided into four task areas involving:

1. Quality Assurance System Audits — an initial on-site review of laboratories and field sites.
2. Quality Control Reference Sample Audits — a sample submissions audit program to the laboratories.
3. Calibration Performance Audits — on-site field calibration audits.
4. Technical assistance to the laboratories, as required.

All work carried out by Rockwell in connection with these tasks is summarized in the results section; the main conclusions for each task area are presented below.

System Audits

Air Monitoring Programs —

A total of thirty-six laboratories and associated field sites were visited, inspected and evaluated by EMSC personnel. The system audit reports contain a great deal of information concerning organization, staffing, laboratory and field equipment, operations and procedures, documentation, data handling, and data validation. The individual reports should be consulted for specific information.

The one major deficiency found in the operation of most of the agencies audited was the lack of a comprehensive written quality assurance plan. While many agencies designated some individual to be the part-time quality assurance coordinator, the duties and authority of this individual were almost never well defined or effectively implemented. Because QA Plans were not thoroughly developed, deficiencies associated with poor documentation, lack of written operating procedures, inadequate quality controls, and nontraceable standards were widespread among most of the agencies.

As state and local agencies, as well as private operators begin to implement the requirement of 40 CFR Part 58, many of the deficiencies uncovered in the system audits will undoubtedly disappear.

U.S. Geological Survey Field Stations —

A total of sixteen laboratories were evaluated. The activities of each individual laboratory were reported in separate formal reports. In these reports which include general laboratory facilities, laboratory functions, quality assurance and data handling, the findings of the overall survey are discussed and compared collectively and general conclusions are shown.

The findings of the overall survey were summarized in an executive summary report covering all sixteen laboratories. This report was written by Dr. George Colovos and Dr. Matt Yoong and submitted to the Project Officer in June 1980. The summary report as well as the individual laboratory reports should be consulted for specific details. The reports may be obtained by contacting the Environmental Monitoring and Support Laboratory in Cincinnati, Ohio.

Quality Control Reference Sample Audits

Performance audit results for all chemical analyses exhibited steady improvement over four years of quarterly audits. The results for sulfate and nitrate showed the largest improvement in the first year of the program. The sulfur dioxide analysis results remained nearly constant for the first three years of the program, with a marked improvement exhibited in the last year. The analytical results for nitrogen dioxide are significantly better than those for sulfate, nitrate, and sulfur dioxide. There was a marked improvement in results during the first year of the program, followed by steadily improving performance. The results for carbon monoxide analysis are noteworthy for consistently high quality throughout the program.

The weighing accuracy for all participating laboratories seemed to be quite satisfactory. In most cases, the weight differences were traceable to faulty balances. In the high volume survey, improvements in performance have been notable. In the last two years of the program, over half of the participating agencies reported errors of less than 5%.

Performance Audits

A major achievement of the program was the marked improvement in the calibration accuracy observed for several pollutants, especially nitric oxide, nitrogen dioxide, nitrogen oxides, and ozone. The data are summarized in the table presented in the results section. The results of over 420 calibration audits provide clear indication of the trend toward improved performance of the participating agencies for all criteria pollutants. This is a clear demonstration of the impact of repeated QA audits on the quality of the data generated by the participating agencies.

Technical Assistance

Technical assistance was needed in several major areas: (a) air monitoring and quality assurance procedure, (b) chemical analysis and quality control procedure, (c) split sample analysis of trace metals, (d) certification of traceability to NBS standards, (e) special audits, and (f) guidelines reviews and publications.

Recommendations

The improvement detected in the calibration of ambient air analyzers and the documentation provided by the performance audit and the reference sample audit reports lends justification to a full implementation of, at least, a minimal QA Plan as promulgated in 40 CFR part 58 Appendices A-E.

Continued support by a third party (neither the monitoring agency nor the regulatory agency) is important to sustain generation of quality ambient air monitoring data.

Results

The results presented in this section are an abbreviated summary of the data obtained in (a) Quality Control Reference Sample Audits and (b) Performance Audits. The complete data summary for the entire program can be found in the final report.

Quality Control Reference Sample Audits

Regularly scheduled Quality Control Reference Sample Audits were carried out for the following analyses or measurements: (1) sulfate/nitrate ($SO_4^=/NO_3^-$) analysis; (2) sulfur dioxide (SO_2) analysis; (3) nitrogen dioxide (NO_2) analysis; (4) carbon monoxide (CO) analysis; (5) weighing performance; and (6) high volume flow rate measurement.

In the chemical analysis survey for $SO_4^=/NO_3^-$, SO_2, NO_2, and CO, Rockwell obtained from commercial vendors, either directly or through EPA, multiple sets of the appropriate samples. Five or ten replicate samples were first analyzed at Rockwell, and the mean value of the analyses was defined as the "true" value. Samples were then submitted for analysis to the participating laboratories. The results of all the participants were compared to the "true" value to determine their accuracy.

To assure the correctness of the Rockwell "true" value, several internal and external quality control procedures were used. External quality control was provided by comparing the Rockwell "true" value with the mean value obtained through replicate sample analysis by either the Quality Assurance Division (QAD-EMSL) laboratory or by the vendor. This comparison was included in each report.

The method for evaluating laboratory performance was to calculate average percent differences between the laboratory analysis values and the "true" values. The average percent differences and the standard deviation of the individual percent differences were tabulated for each laboratory that participated in the quarterly audit as measures of analytical error. The calculations are explained in detail in 40 CFR Part 58 Ambient Air Quality Surveillance — Appendix A: Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS). The major difference between the Rockwell procedure and that described in the SLAMS regulations is that the latter specifies three concentration ranges: 0.2 - 0.3 $\mu g/ml$; 0.5 - 0.6 $\mu g/ml$; and 0.8 - 0.9 $\mu g/ml$ for both SO_2 and NO_2. In the current Rockwell program there are three to six samples and the concentrations of the audit samples cover a much wider range. Another difference from the EPA regulations is that our program included audits of CO, $SO_4^=$, and NO_3^- analysis, none of which are required by the new regulation.

The composite performance of all laboratories participating in the surveys is summarized below for each of the pollutants independently.

Composite averages were obtained by combining the quarterly results of each agency using the following equations:

$$\bar{D} = \frac{\sum_{j=1}^{k} n_j \bar{d}_j}{\sum_{j=1}^{k} n_j} \qquad (1)$$

$$S_a = \sqrt{\frac{\sum_{j=1}^{k} (n_j - 1)\, S_j^2}{\sum_{j=1}^{k} (n_j - 1)}} \qquad (2)$$

where $\overline{D}$ and S_a are the composite average percent deviation and the standard deviation, respectively, n_j is the number of samples analyzed by the j^{th} laboratory, $\overline{d}_j$ is the average percent difference for all samples analyzed by the j^{th} laboratory, S_j is the standard deviation, and k is the total number of participating laboratories. In order to avoid undue bias of the results, a laboratory was declared an outlier and the data were not used for computing composite averages if the average percent deviation $\overline{d}_j$ or the standard deviation S_j for that laboratory was equal to or greater than 100 percent. The latter value was chosen arbitrarily so as to eliminate only grossly erroneous data (e.g., decimal point error in the reported data).

To evaluate progress or improvement in overall performance, tables have been prepared showing the percentage of all the analyses in which the error was equal or less than certain specified values, usually 10 or 20%. These values were selected as reasonable targets for analytical accuracy which a large fraction of the laboratories could be expected to meet or exceed. The tables list results for selected sample concentration ranges for each year of the program. The concentration ranges were chosen so that the number of analyses in each range was roughly equal.

Sulfate/Nitrate Analysis —

Table 1 shows that the percentage of all the $SO_4^=$ analyses in which the error was equal or less than 10% increased from 55% on year 1 to 82% on year 4. According to Table 2, the corresponding percentages for NO_3^- analyses was 43% on year 1 and increased to 72% on year 4. The improvement in performance over the four year period is thus clearly evident. In the fourth year of the program, 70-80% of all analyses had errors of less than 10%.

Tables 1 and 2 do not show striking differences in analytical performance between sample concentrations, although as expected the samples having the lowest concentrations result in the lowest fraction of analyses with error of 10% or less.

Sulfur Dioxide Analysis —

Table 3 shows the percentage of analyses with error equal to or less than 10% and 20%. The table indicates that in the first three years of the program the fraction of all the analyses with error of 10% or less remained nearly constant at about 65%, while in the last year the fraction of analyses with error of 10% or less increased to 83%. In all four years, the fraction of analyses with error of 10% or less was significantly lower for samples below 20 g/m³ than for the higher concentration samples.

Table 1. Summary of Agency Performance for $SO_4^=$ Analysis

Sample Concentration Range* µg/m³	Percent Analyses With Error ≤ 10%				Percent Analyses With Error ≤ 20%			
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 1	Yr 2	Yr 3	Yr 4
1-5	47	38	36	61	59	62	67	89
5-15	58	77	66	88	80	91	87	100
15-25	63	80	77	79	88	88	92	98
> 25	50	48	79	90	88	78	93	100
All	55	62	67	82	75	80	86	98

**The air flow was assumed to be 2000 m³, and the filter strips were assumed to represent 1/12 of a standard high-volume filter. Thus the weight in µg of the sample actually analyzed is obtained by multiplying the sample concentration in µg/m³ by the ratio 2000/12.*

Table 2. Summary of Agency Performance for Analysis of NO_3^-

Sample Concentration Range* µg/m³	Percent Analyses With Error ≤ 10%				Percent Analyses With Error ≤ 20%			
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 1	Yr 2	Yr 3	Yr 4
0-2	29	38	40	67	47	71	79	83
2-5	56	27	59	83	81	87	82	89
5-9	44	56	72	69	73	89	87	82
9-14	53	71	70	75	88	95	88	83
All	43	51	63	72	69	83	85	83

**The air flow was assumed to be 2000 m³, and the filter strips were assumed to represent 1/12 of a standard high-volume filter. Thus the weight in µg of the sample actually analyzed is obtained by multiplying the sample concentration in µg/m³ by the ratio 2000/12.*

Table 3. Summary of Agency Performance for SO_2 Analysis

Sample Concentration Range* µg/m³	Percent Analyses With Error ≤ 10%				Percent Analyses With Error ≤ 20%			
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 1	Yr 2	Yr 3	Yr 4
10-20	39	38	21	28	54	64	36	67
35-85	58	68	65	89	88	81	76	98
90-130	83	78	89	100	93	84	89	100
150-230	79	73	77	96	93	83	95	100
All	63	66	65	83	83	79	73	94

**The air flow was assumed to be 300 liters and the sulfite salt was dissolved in 50 ml of solution. To convert sample concentration from µg/m³ multiply by the ratio 0.300/50.*

Nitrogen Dioxide Analysis —

Table 4 summarizes the composite results. A close examination of the table and comparison with the corresponding results for $SO_4^=$, NO_3^-, and SO_2 indicate clearly that analytical results for NO_2 are significantly better than for the other three analytes. Except for the first year, over 80% of all the analyses showed errors of 10% or less. In the fourth year of the program, over 90% of the analyses resulted in errors of 10% or less. In general the higher the sample concentration, the better the results.

Carbon Monoxide Analysis —

The results of all CO surveys were for the most part very satisfactory. Table 5 summarizes the agency performance by showing the fraction of all the analyses in which the error was equal or less than 5% and 10%. The lower target error of 5% was used because of the relatively good results for CO. Table 5 shows that the fraction of all the analyses with error

of 5% or less increased from 60% in the first year to 82% in the fourth year. In all four years of the program, approximately 90% of all the analyses resulted in errors of 10% or less.

Weighing Survey —

Three weighing performance audits were conducted to test weighing accuracy of the participating laboratories. The audits were conducted in 1977, 1978 and 1979. For weighing audits sets of 3 weights, each containing 1g, 2g, and 5g nominal weights, were sent to participating agencies, which then weighed the objects and reported results to Rockwell.

Table 6 summarizes the weighing results for each of the three surveys. In general, weighing performance has been quite satisfactory. In 1977, three agencies out of sixteen reported weights which differed from the "true" weights by more than 1 mg. In 1979, three agencies out of twenty-eight had a weighing problem. In most cases the weight differences were traceable to faulty balances.

High-Volume Flow Rate Calibration Audits —

A flow rate calibration audit was conducted during each year of the program. Table 7 presents a summary of the results of the four performance audits. The table gives the percent of sites in which the calibration error falls within the specified error ranges shown in the first column. The results demonstrate how the performance has improved in the four years of the program. In the first year, only 20% of the surveyed sites reported errors of less than 5%, whereas in the third and fourth years the fraction of sites with errors of less than 5% increased to 57% and 59%, respectively.

Performance Audits

Performance audits of air monitoring stations operated by participating groups were major tasks in the Western and Eastern QA programs. The total number of station audits is approximately 425. Individual reports for these audits have been issued and are on file with EPA in RTP. These reports should be consulted for detailed results and discussion. Generally, each audit report refers to only one agency and describes the results obtained for several stations audited during one trip. Detailed audit

Table 4. *Summary of Agency Performance for Analysis of NO_2*

Sample Concentration Range µg/m³	Percent Analyses With Error ≤ 10%				Percent Analyses With Error ≤ 20%			
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 1	Yr 2	Yr 3	Yr 4
0.10-0.21	31	43	56	92	64	77	100	100
0.22-0.38	72	84	74	95	97	98	88	100
0.39-0.68	75	95	90	85	94	98	96	100
0.69-1.02	81	100	92	93	93	100	95	98
All	64	83	86	91	87	94	94	99

Table 5. *Summary of Agency Performance for Analysis of CO*

Sample Concentration Range ppm	Percent Analyses With Error ≤ 5%				Percent Analyses With Error ≤ 10%			
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 1	Yr 2	Yr 3	Yr 4
3-10	34	45	54	63	76	67	82	79
15-30	73	77	82	92	97	97	97	97
34-50	73	91	89	93	96	100	95	100
All	60	71	75	82	90	88	91	92

Table 6. *Summary of Agency Performance for Weighing Audit*

	Year 1 1977			Year 2 1978			Year 3 1979		
No. of Agencies Participating	16			15			28		
Nominal Weight	1g	2g	5g	1g	2g	5g	1	2g	5g
Total Number of Weighings	19	19	19	17	17	17	30	30	30
No. of Weighings With Difference of 0.5 mg or less	14	12	14	14	15	14	21	21	20
No. of Weighings With Difference of 1.0 mg or less	15	14	15	17	17	17	28	27	28

Table 7. *Summary of High Volume Flow Rate Audits*

	Year 1 1977	Year 2 1978	Year 3 1979	Year 4 1980
Number of Agencies	15	16	26	26
Number of Sites	40	38	126	58
Calibration Error Range	Percentage of Sites			
0 - 5%	20	39.5	57.1	58.6
5 - 10%	37.5	55.3	28.6	13.8
10 - 15%	15	2.6	6.3	1.7
15 - 20%	20	2.6	3.2	1.7
20 - 25%	0	0	3.2	0
25 - 30%	0	0	1.6	0
> 30%	7.5	0	0	6.9

procedures are described in the final report.

The method adopted for reporting audit results compares the concentrations delivered to the analyzer from the audit device to those predicted from the observed instrumental response and the latest station multipoint calibration. Mathematically, the results are expressed in the form $C_2 = \alpha + \beta C_1$, where C_2 is the station concentration, C_1 is the audit concentration, β is the slope, and α is the intercept. Perfect agreement between station and audit is represented by the "unity line" $\beta = 1$, $\alpha = 0$. Audit reports show graphs of C_2 vs C_1, and the values of α and β are given in tabular form. The advantage of this method is that β is non-dimensional, and its value is independent of the analyzer range and the units used to express analyzer output.

The percent difference between station concentrations are readily expressed in terms of the magnitude of α and β by means of the equation:

$$\% \text{ diff} = 100 \times \frac{C_2 - C_1}{C_1}$$

$$= 100 \quad (\beta - 1) + \frac{\alpha}{C_1} \qquad (3)$$

In order to evaluate the station performance the percent difference is calculated at the nominal full scale of the analyzer (for example: $C_1 = 0.5$ ppm for most NO analyzers). Since normally the magnitude of α/C_1 is small compared to $\beta - 1$, the percent difference is approximately a constant represented by the quantity $100(\beta - 1)$. This latter relationship makes β a useful comparison parameter.

For purposes of the Rockwell audits, the following working guidelines were adopted:

Discrepancies of 10% or less at full scale required no specific corrective action and were considered "satisfactory."

Discrepancies in excess of 10% at full scale were of immediate concern. In such cases, Rockwell made a specific attempt to locate the source of the problem and, if this was not practical, likely sources of error were identified and recommendations were made to the agencies for further study. A typical recommendation was for the agency to re-calibrate the analyzer in question.

Table 8 summarizes overall performance in tabular form for each type of pollutant. The table shows the total number of audits, the average percent error at full scale (without regard to the sign) and the percent of audits in which the error is equal or less than 5%, 10%, and 15%. The entries in Table 8 are arranged by program year (October 1 to September 30).

Table 8 presents clear evidence of the impact of repeated QA audits on the quality of the data generated by the participating groups. The most remarkable improvement in calibration accuracy is noted for NO, NO_x and NO_2. For example the average percent error for NO decreased steadily from 15.5% in the first year to 6.2% in the fourth year and also the fraction of audits in which the error was 10% or less increased from 59% in the first year to 83% in the fourth year. Similar results are observed for NO_x and NO_2. The overall performance for O_3 calibration has undergone significant improvement as the average percent error decreased from 13.6% in the first year to 7.0% in the fourth year. However the change is not as pronounced as that for NO-NO_x.

For SO_2, a somewhat different pattern is observed. In the first year of the

Table 8. Summary of Audit Results

Year	No. of Audits	Ave. % Error	Percent Audits Error ≤ 5%	Percent Audits Error ≤ 10%	Percent Audits Error ≤ 15%
			NO		
1	34	15.5	32	59	65
2	65	8.8	49	74	83
3	56	7.1	50	75	88
4	23	6.2	61	83	96
			NO_x		
1	28	16.6	39	50	57
2	58	7.8	53	76	84
3	57	7.3	49	81	88
4	19	4.3	68	89	100
			NO_2		
1	24	17.5	33	46	63
2	53	7.4	58	81	83
3	74	8.4	36	74	84
4	24	3.9	71	100	100
			O_3		
1	36	13.6	28	64	72
2	90	10.8	38	54	72
3	101	9.5	41	61	77
4	29	7.0	62	76	83
			SO_2		
1	64	15.8	36	58	66
2	100	8.8	42	72	84
3	128	8.2	45	74	84
4	46	9.6	37	72	83
			CO		
1	23	8.2	17	83	96
2	57	4.7	63	88	98
3	68	4.3	65	96	100
4	22	4.0	73	100	100
			CH_4/THC		
1	27	10.1	44	78	89
2	43	6.5	63	77	95
3	35	4.2	65	94	100
4	16	5.1	75	88	94

program, the average percent error was about 16%, while in the remaining three years the average percent error remained nearly constant at 8-9%. Several groups displayed large calibration differences in the beginning of the program which were caused by procedural or calculation errors. After these large errors were discovered and eliminated, the performance has remained nearly constant, indicating that 8-9% is the best that can be expected for the current calibration methods.

The average percent error for CO has been less than 5% since the second quarter of the program. Also, the percent of audits in which the error was 10% or less has been above 80% from the start of the program. This is excellent agreement and it clearly indicates that calibration of CO presents no difficulties. This conclusion is consistent with the results of the interlaboratory CO performance audits.

The situation for CH_4/THC is somewhat comparable to that of SO_2 in that most of the observed improvement occurred after the first year of the program. In general the CH_4/THC results have been quite satisfactory in that the percentage of audits in which the error was 10% or less has been 77% or higher throughout the program.

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The complete report, entitled "Quality Assurance in Support of Energy Related Monitoring Activities: Final Report," (Order No. PB 82-234 311; Cost: $10.50, subject to change) will be available only from:
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